

# REPORT DOCUMENTATION PAGE

Form Approved  
OMB NO. 0704-0188

Public Reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comment regarding this burden estimates or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188,) Washington, DC 20503.

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE	7 May, 2001	3. REPORT TYPE AND DATES COVERED Final Progress Report, 1 Jul 00 – 30 Jun 01
4. TITLE AND SUBTITLE Concept Studies of Micro-Pump for Chemical Concentration in Handheld Micro Sensors		5. FUNDING NUMBERS G – DAAD19-00-1-0438	
6. AUTHOR(S) Jian-Qiao Sun			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of Delaware, Department of Mechanical Engineering 126 Spencer Lab Newark, DE 19716		8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U. S. Army Research Office P.O. Box 12211 Research Triangle Park, NC 27709-2211		10. SPONSORING / MONITORING AGENCY REPORT NUMBER <i>41492.1-CH-11</i>	
11. SUPPLEMENTARY NOTES The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.			
12 a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited.		12 b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words)  This report summarizes the preliminary results of a short-term innovative research project on the concept study of micro pumps for chemical concentration in handheld micro sensors. The work conducted under this project is a six-month concept study. The application target of the research is to help improve the sensitivity of the chemical agent sensor using conductive polymer developed at the Army Research Laboratory in Aberdeen, Maryland. The main objective of the work is to study the feasibility of certain micro pumping concepts and their potential integration with the sensing material and the electronics. A prototype of a mini pump is presented, which has a potential to be miniaturized. The feasibility of sample concentration by using micro pumps is demonstrated, although the quantitative assessment of the pumping system is still elusive, partly because of lack of specifications. The future research efforts to improve the micro pumps and to miniaturize them are also outline in the report.			
14. SUBJECT TERMS Micro pumps, miniaturization, sample concentration, chemical sensors			15. NUMBER OF PAGES 2
			16. PRICE CODE
17. SECURITY CLASSIFICATION OR REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION ON THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL

NSN 7540-01-280-5500

Standard Form 298 (Rev.2-89)  
Prescribed by ANSI Std. Z39-18  
298-102

**20010725 028**

**MEMORANDUM OF TRANSMITTAL**

U.S. Army Research Office  
ATTN: AMSRL-RO-BI (TR)  
P.O. Box 12211  
Research Triangle Park, NC 27709-2211

<input type="checkbox"/> Reprint (Orig + 2 copies)	<input type="checkbox"/> Technical Report (Orig + 2 copies)
<input type="checkbox"/> Manuscript (1 copy)	<input checked="" type="checkbox"/> Final Progress Report (Orig + 2 copies)
<input type="checkbox"/> Related Materials, Abstracts, Theses (1 copy)	

CONTRACT/GRAANT NUMBER: G DAAD19-00-1-0438

REPORT TITLE:

**Concept Studies of Micro-Pump for Chemical Concentration in Handheld Micro Sensors**

is forwarded for your information.

SUBMITTED FOR PUBLICATION TO (applicable only if report is manuscript):

Sincerely,



Jian-Qiao Sun  
University of Delaware

---

## REPORT DOCUMENTATION PAGE (SF298) (Continuation Sheet)

---

### **Statement of the Work**

The work conducted under this project is a six-month concept study. The application target of the research is to help improve the sensitivity of the chemical agent sensor using conductive polymer developed at the Army Research Laboratory in Aberdeen, Maryland. The main objective of the work is to study the feasibility of certain micro pumping concepts and their potential integration with the sensing material developed by Army personnel and with the electronics developed in the companion project lead by Professor C. S. Ih of the University of Delaware.

### **Summary of the Results**

Modern semi-conductor manufacturing industry has created many new applications in chemical and bio-science areas. A recent advance in this regard is the creation of micro chemical laboratory and bio-sensors on a chip [1-3]. Such a technology can provide hand-held devices for detecting different chemical agents in the air and in the water. There have been many studies of different sensing mechanisms including using conductive polymers for detecting gases [4]. However, there is less study on developing integrated signal processing and amplification system on the same chip and a micro-pump driven chemical concentrator for the eventual product of the research, a handheld chemical sensor. Because the sensor signals in many micro sensors are extremely small and are prone to electrical noise interference, it is an extremely difficult technical task to bring the signals out to provide readable information for the users. A companion project to the present one is to develop an on-chip signal conditioning and amplifying device. That project is entitled "Prototype of On-Chip Signal Processing for Handheld Chemical Agent Sensors" lead by Professor C. S. Ih of the Department of Electrical and Computer Engineering, University of Delaware.

The application target of the research is to help improve the sensitivity of the chemical agent sensor using conductive polymer developed at the Army Research Laboratory in Aberdeen, Maryland. The main objective of this project is to study the feasibility of certain micro pumping concepts and their potential integration with the sensing material developed by Army personnel and with the electronics developed in the companion project. In the past year, we have developed a prototype of micro pump for sample concentration, and have delivered the device to the above-mentioned Army Laboratory for testing.

To conduct the concept study, we built a mini-pump that has a potential to be miniaturized. A three-piece diaphragm pump has been acquired and tested in our laboratory. The components of the pump are shown in Figure 1. This mini-pump has an overall dimension  $20 \times 20 \text{ mm}^2$ . With a small DC motor and 6V input voltage, the pump pumps 1100 milliliter per minute. The mini-pump has been tested in sample concentration experiments. The fluid is pumped through a small channel in a plexiglass body as shown in Figure 2. A undergraduate student and a visiting professor in the Department of Electrical and Computer Engineering have been working on this project.

The capability of the micro pumping system should be developed to match the need of through-put of the flow as required for the sample concentration for a specific chemical sensor. In this project, we have not acquired any specification for the sample concentration. As a result, a quantitative assessment of the ability of the pumping power is not done, although in many sample concentration experiments, we have seen color changes of the porous materials placed in the flow path of standard buffer solution (pH 7.00).

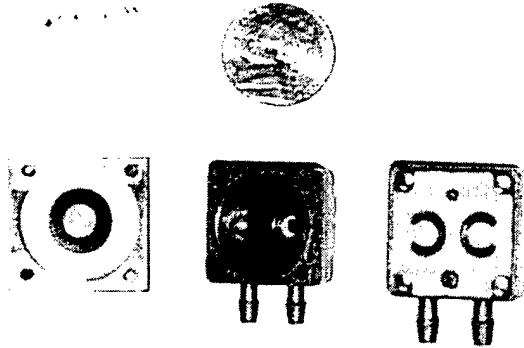


Figure 1. The three-piece diaphragm pump. On the right is the diaphragm-pumping element, in the middle is the fluid chamber, and on the right is the valve made of a diaphragm. The size of the pump is  $20 \times 20$  mm $^2$ , about the size of a nickel.

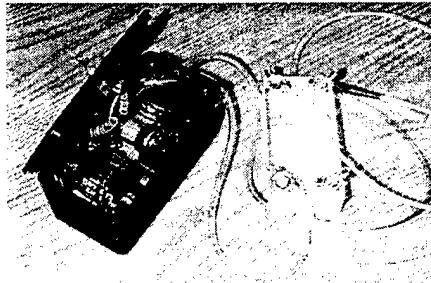


Figure 2. The mini-pump and the battery are contained in the black box, and the transparent plexiglass body is connected to the pump, and has fluid channels surface-machined in the middle, leading to the sensory material. A small hole on the top of the sensing area allows the fiber optical probe to take the reading from the sensor. In the proposed research, the light path for the laser measurement system can also be surface-machined in the plexiglass body.

What has been achieved in this small-scale and short exploration demonstrates the potential of miniaturizing pumps for hand-held chemical and biological agent detection device. Much more future work needs to be done. For example, we need to quantify the capability of sample concentration as a function of the pump power consumption, to miniaturize the pump by using the surface machining technology, and to develop an integrated systems with the sensors and the supporting electronics. This can be readily evolved into a multiple year project.

#### List of Participating Scientific Personnel

Professor Baohua Zhuang, Department of Electrical and Computer Engineering, University of Delaware  
Scott Hansen, Senior undergraduate student, BS 2001, Mechanical Engineering, University of Delaware

#### Cited References

1. D. Barrow, J. Cefai and S. Taylor 1999 *Chemistry and Industry* (15), 591-594. Shrinking to fit.
2. S. Cowen 1999 *Chemistry and Industry* (15), 584-586. Chip service.
3. T. McCready 1999 *Chemistry and Industry* (15), 588-590. Reducing the risks of synthesis.
4. M. S. Freund and H. S. Lewis 1995 *Proceedings of National Academy of Science of USA* **92**, 2652-2656. A chemically diverse conducting polymer-based "electronic nose".